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Pattern recognition in digital images by binary concentric rings optimal masks

Reconocimiento de patrones en imágenes digitales mediante máscaras óptimas de anillos concéntricos

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ABSTRACT:
In this work a new non-linear correlation digital system invariant to position, rotation, scale and resolution based on optimal masks and the one-dimensional signatures methodology is presented.

Key words: Optimal mask, one-dimensional signature, non-linear correlation.

REFERENCES AND LINKS

1. Introduction
Recently, digital systems invariant correlation to position, rotation and scale are utilized in the pattern recognition field [1]. Such invariants are made by the Fourier and Fourier-Mellin transforms in conjunction with non linear filters (k-law filter). The non linear filters have advantages compared with the classical filters (POF, BAPOF, VanderLugt, CHF) due to their great capacity to discriminate objects, the maximum value of the correlation peak is well localized, and the output plane is less noisy [2]. In order to have a new non-linear correlation digital system
invariant to position, rotation, scale and resolution in this work a new methodology based on one-dimensional signatures of the images is presented. This new algorithm uses optimal masks to obtain resolution invariant.

2. The digital system

2.a.- The optimal masks

The masks associated of a given square image $I$ of size $N \times N$ are built by taking the real and imaginary parts of its 2D-Fourier transform ($FT(I)$). Results of both images are filtered by a mask of a binary disk of diameter equal to $N$. After that, 180 profiles with length $N$ are obtained for each Fourier plane image. These profiles pass for the centre of the image $(c,c)$ and they ending in the disk’s border. The profiles are separated by 1 deg, sampling of this way the entire circle. The next step is to compute, for the real part, the addition of the intensity values in each profile and select the profile whose sum has the maximum value; it is called the optimal profile $f_{FR}$. Analogously for the imaginary part, the optimal profile $f_{FI}$ is calculated. From $f_{FR}$ two binary functions are built by

$$Z_p^{FR}(x) = \begin{cases} 1 & \text{if } f_{FR}(x) > 0 \\ 0 & \text{if } f_{FR}(x) \leq 0 \end{cases} \quad Z_p^{FI}(x) = \begin{cases} 1 & \text{if } f_{FI}(x) > 0 \\ 0 & \text{if } f_{FI}(x) \leq 0 \end{cases}$$

where $x=1, \ldots, N$. For $f_{FI}$ only the binary function $Z_p^{FI}$ is obtained as eq. (1). This three binary function are symmetric in $x=c$. Taking $x=c$ as the rotation axis, the graph of $Z_p^{FR}$, $Z_p^{FR}$ and $Z_p^{FI}$ are rotated 180 degrees to obtain three optimal masks, $M_{FRP}$, $M_{FRNP}$, $M_{FIP}$, of concentric rings with different widths and centred in $(c,c)$ associated to the images $I$. Based on these optimal masks, three one-dimensional signatures are computed using the Fourier-Mellin transform like [1]. The average of them is called the average-signature of the image $I$.

2.b.- The pattern recognition

Let $A$ the set of $n$ reference image ($RI$). Then, $n$ average-signatures are computed as section 2.a. If a problem image ($PI$) will be classified, its average-signature is build using the $M_{FRP}$, $M_{FRNP}$, $M_{FIP}$, of $RI_k \in A$. If the maximum value of the magnitude for the non-linear correlation [2] are significant, that is similar to the autocorrelation maximum value, hence the $PI$ contains the $RI_k$, otherwise are different. Moreover, the $PI$ could had a different resolution of that images in $A$ and the digital system classified it. The resolution invariant is achieved by the uses of the same three optimal masks of the $RI_k$ to make the average-signature of the $PI$.

3. Conclusions

This work presents a low computational cost algorithm invariant to position, rotation, scale and resolution. The digital system was tested using a database of BW Arial font letter and it presents an excellent performance, a confidence level of 95.4% or greater.

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